

**FINAL REPORT FOR NASA GRANT NAG5-2997, ANALYSIS OF DATA FROM THE
TRANSIENT GAMMA-RAY SPECTROMETER EXPERIMENT ON THE GGS/WIND
SPACECRAFT**

The data analysis from the TGRS experiment is continuing, although the UC Berkeley PI, K. Hurley, is no longer funded for this effort. This experiment has been returning data on the energy spectra and time histories of cosmic gamma-ray bursts since November 1994, and continues to operate in good health. Over a 3 year period ending in November 1997, 41 bursts have been detected simultaneously by TGRS and Dr. Hurley's Ulysses gamma-ray burst experiment. By comparing the times of arrival of a burst at Ulysses and TGRS, we can obtain an annulus of arrival directions for the event. Typical 3σ annulus widths range from several arcminutes to tens of arcminutes. Because the WIND spacecraft is as far as several light-seconds from Earth, it is sometimes possible to obtain a second annulus using the Burst and Transient Source Experiment (BATSE) aboard the GRO spacecraft. 23 of the 41 bursts were also observed by this experiment. Generally, the two annuli intersect at grazing incidence, leading to a long, narrow error box which reduces somewhat the error circles obtained from BATSE alone. Table 1 summarizes the burst data from TGRS. We plan to defer the publication of these locations until a larger number of events has been accumulated.

Measuring the energy spectra of cosmic gamma-ray bursts to search for line emission is one of the prime objectives of this experiment. However, an intense gamma-ray burst is required, or the statistics become too weak to draw meaningful conclusions. One such event has occurred to date, on August 22, 1995, and we have examined it in detail. The spectrum shows no evidence for lines, however. The results have been reported in Seifert et al., 1997 (see Appendix 1).

A final objective has been to monitor the annihilation line from the galactic center. Results on this line have been published by Teegarden et al. (1996).

A summary of all publications in which the UC Berkeley PI has played a role appears in Appendix 1.

Table 1

THE FOLLOWING SPACECRAFT DATA HAVE BEEN EXAMINED

1. ULY -ULYSSES
2. BAT -BATSE/GRO
3. OSS -OSSE/GRO
4. COM -COMTEL/GRO
5. EGR -EGRET/GRO
6. PVO -PIONEER VENUS ORBITER
7. GIN -GINGA - LANL EXPERIMENT
8. DMS -DEFENSE METEOR. SAT. PROGRAM
9. NAT -WATCH/GRANAT
10. SIG -SIGMA/GRANAT
11. PHE -PHEBUS/GRANAT
12. COR -CORONAS -USSR MISSION - HAZETS
13. YOH -YOHKOH
14. EUR -WATCH/EURECA
15. MO -MARS OBSERVER
16. TGR -TGRS/WIND
17. KON -KONUS/WIND
18. SAX -ITALIAN X-RAY ASTRONOMY SAT.
19. HET -HETE
20. SRS -SROSS-C

EXPLANATION OF OTHER SYMBOLS USED

NSAT-REFERS TO SPACECRAFT FOR WHICH EVENT TIME IS GIVEN
ECW, VCN, MCW, AND UCV ARE THE EARTH, VENUS, MARS,
AND ULYSSES CROSSING WINDOWS IN SECONDS
EVENT IDENT.-EVENTS ARE CATEGORIZED AS CONFIRMED
OR UNCONFIRMED COSMIC OR SOLAR, BLANK (CANDIDATE)
TRIGGERED BY COMMAND, STATISTICAL FLUCTUATION, PARTICLE-INDUCED
CONFIRMED OR UNCONFIRMED SOFT GAMMA REPEATER
CONFIRMED OR UNCONFIRMED EVENT FROM SGR1806-20, OR SGR1900+14
SYMBOLS IN SPACECRAFT COLUMNS (ULY,BAT, OSS, ETC) ARE AS FOLLOWS
YES MEANS THAT THE EXPERIMENT TRIGGERED ON THE EVENT
BLANK MEANS UNKNOWN - DATA NOT EXAMINED

RI MEANS RATE INCREASESERVABLE WITH THIS SPACECRAFT

NO MEANS NO TRIGGER OR RATE INCREASE, BUT THE EVENT WAS OBSERVABLE

COMMENTS REFER TO PRECEDING LINE

DATE	DOY	TIME	T,SEC	NSAT	ECW	VCW	MCW	UCW	EVENT IDENT.	ULY	BAT	OSS	COM	ECR	PVO	GIN	DMS	WAT	SIG	PHE	COR	YOH	EUR	MO	TGR	KON	SAX	HET	SR5							
1.19	NOV	94	323	19:30:50	70250	2	0	150	596	1085	CONF.	COSMIC	RI	YES		N/O	N/O												N/O	N/O	YES	YES	N/O	N/O		
COMMENT.....BATSE #3287																																				
2.21	NOV	94	325	17:24:57	62697	2	0	154	587	1082	CONF.	COSMIC	YES	YES		N/O	N/O												N/O	N/O	YES	YES	N/O	N/O		
COMMENT.....BATSE #3290																																				
3.26	NOV	94	330	12:22:01	44521	2	0	167	566	1076	CONF.	COSMIC	YES	YES		N/O	N/O												N/O	N/O	YES	YES	N/O	N/O	YES	
COMMENT.....BATSE #3298																																				
4.	JAN	95	4	07:18:39	26319	2	0	299	411	1095	CONF.	COSMIC	RI	YES		N/O	N/O												N/O	N/O	YES	YES	N/O	N/O		
COMMENT.....BATSE #3345																																				
5.11	JAN	95	11	12:18:30	44310	2	0	326	388	1106	CONF.	COSMIC	RI	YES		N/O	N/O												N/O	N/O	RI	YES	N/O	N/O		
COMMENT.....BATSE #3352																																				
6.14	JAN	95	14	13:10:35	47435	16	0	337	380	1111	CONF.	COSMIC	YES	NO		N/O	N/O												N/O	N/O	YES	YES	N/O	N/O		
7.	APR	95	97	15:15:32	54932	16	0	632	471	1114	CONF.	COSMIC	YES	NO		N/O	N/O												YES	N/O	N/O	YES	YES	N/O	N/O	YES
8.	AUG	95	216	01:58:54	7134	2	0	860	935	1137	CONF.	COSMIC	YES	YES		N/O	N/O												YES	N/O	N/O	YES	YES	N/O	N/O	
COMMENT.....BATSE #3734																																				
9.	AUG	95	217	03:44:14	13454	2	0	860	937	1141	CONF.	COSMIC	RI	YES		N/O	N/O												N/O	N/O	YES	YES	N/O	N/O		
COMMENT.....BATSE #3736																																				
10.	AUG	95	221	23:52:25	85945	2	0	861	949	1157	CONF.	COSMIC	RI	YES		N/O	N/O												N/O	N/O	YES	YES	N/O	N/O		
COMMENT.....BATSE #3750																																				
11.18	AUG	95	230	01:23:22	5002	2	0	862	973	1194	CONF.	COSMIC	YES	YES		N/O	N/O												N/O	N/O	YES	YES	N/O	N/O		
COMMENT.....BATSE #3765																																				
12.22	AUG	95	234	03:49:09	13749	2	0	862	984	1210	CONF.	COSMIC	YES	YES		N/O	N/O												YES	N/O	N/O	YES	YES	N/O	N/O	
COMMENT.....BATSE #3767																																				
13.14	OCT	95	287	03:38:28	13108	17	0	821	1089	1387	CONF.	COSMIC	YES	NO		N/O	N/O												N/O	N/O	YES	YES	N/O	N/O		
14.13	NOV	95	317	23:25:56	84356	2	0	771	1126	1424	CONF.	COSMIC	RI	YES		N/O	N/O												N/O	N/O	RI	YES	N/O	N/O		
COMMENT.....BATSE #3906																																				
15.19	NOV	95	323	08:17:12	29832	2	0	759	1132	1425	CONF.	COSMIC	RI	YES		N/O	N/O												N/O	N/O	YES	YES	N/O	N/O		
COMMENT.....BATSE #3912																																				

16.19 NOV 95 323 12:54:17 46457 17	0	759	1132	1425	CONF.	COSMIC	RI	NO	N/O N/O	N/O N/O RI	YES N/O N/O
COMMENT.....BAYSE #3929											
17.22 NOV 95 326 04:45:07 17107 17	0	753	1135	1425	CONF.	COSMIC	RI	NO	N/O N/O	N/O N/O YES YES	N/O N/O
18. 2 DEC 95 336 10:51:40 39100 2	0	731	1143	1423	CONF.	COSMIC	RI	YES	N/O N/O	N/O N/O RI	YES N/O N/O
COMMENT.....BAYSE #3930											
19. 3 DEC 95 337 01:06:28 3988 2	0	729	1144	1423	CONF.	COSMIC	YES	YES	N/O N/O	N/O N/O YES YES	N/O N/O
COMMENT.....BAYSE #3937											
20. 8 DEC 95 342 11:47:23 42443 2	0	718	1147	1421	CONF.	COSMIC	RI	YES	N/O N/O	N/O N/O RI	YES N/O N/O
COMMENT.....BAYSE #3954											
21.13 DEC 95 347 04:57:32 17852 2	0	706	1151	1418	CONF.	COSMIC	RI	YES	N/O N/O	YES N/O N/O YES YES	N/O N/O
COMMENT.....BAYSE #4048											
22.20 DEC 95 354 08:51:21 31881 2	0	689	1155	1413	CONF.	COSMIC	RI	YES	N/O N/O	N/O N/O RI	YES N/O N/O
COMMENT.....BAYSE #4368 ALSO OBSERVED BY KORUS-A											
23.27 DEC 95 361 06:23:25 23005 17	0	671	1159	1408	CONF.	COSMIC	YES	NO	N/O N/O NO	N/O N/O YES YES	N/O N/O
COMMENT.....BAYSE #4556 ALSO OBSERVED BY KORUS-A											
24.14 JAN 96 14 12:15:04 44104 2	0	621	1168	1399	CONF.	COSMIC	YES	YES	N/O N/O	N/O N/O YES YES	N/O N/O YES
COMMENT.....BAYSE #5614											
25.24 JAN 96 24 00:56:26 3386 2	0	592	1172	1399	CONF.	COSMIC	YES	YES	N/O N/O	N/O N/O YES YES	N/O N/O
COMMENT.....BAYSE #6168											
26.24 SEP 96 268 11:41:50 42110 2	0	484	991	2565	CONF.	COSMIC	YES	YES	N/O N/O	N/O N/O YES YES	N/O
COMMENT.....BAYSE #6168											
27.17 JAN 97 17 14:46:51 53211 16	0	792	503	2037	CONF.	COSMIC	YES	NO	N/O N/O NO	N/O N/O YES NO	YES N/O
COMMENT.....BAYSE #6168											
28.24 JAN 97 24 12:50:53 46253 16	0	803	472	2011	CONF.	COSMIC	YES	NO	N/O N/O NO	N/O N/O YES YES	N/O
COMMENT.....BAYSE #6168											
29.11 APR 97 101 09:52:36 35556 16	0	860	351	2204	CONF.	COSMIC	YES	YES	N/O N/O NO	N/O N/O YES YES	N/O
COMMENT.....BAYSE #6168											
30. 6 MAY 97 126 15:41:43 56503 2	0	848	421	2414	CONF.	COSMIC	YES	NO	N/O N/O NO	N/O N/O YES YES	N/O
COMMENT.....BAYSE #6168											
31. 2 JUN 97 153 16:20:56 58856 17	0	817	518	2653	CONF.	COSMIC	YES	NO	N/O N/O YES	N/O N/O YES YES	N/O
COMMENT.....BAYSE #6168											
32.25 JUN 97 176 12:13:15 43995 16	0	774	603	2837	CONF.	COSMIC	YES	NO	N/O N/O RI	N/O N/O YES YES	N/O NO
COMMENT.....BAYSE #6168											
33.27 JUN 97 178 22:06:49 79609 17	0	769	611	2852	CONF.	COSMIC	YES	NO	N/O N/O NO	N/O N/O YES YES	N/O YES
COMMENT.....BAYSE #6168											
34.15 JUL 97 196 14:21:34 51694 8	0	725	674	2966	CONF.	COSMIC	YES	NO	N/O N/O YES	N/O N/O YES YES	N/O YES
COMMENT.....BAYSE #6168											
35.21 JUL 97 202 23:31:12 84672 8	0	709	694	2998	CONF.	COSMIC	YES	NO	N/O N/O YES	N/O N/O YES YES	N/O

36.15 SEP 97 258 09:07:51 32871 17	0	527	856	3101	CONF.	COSMIC	YES	NO	N/O	N/O	YES	YES	N/O
37.19 SEP 97 262 18:14:29 65669 2	0	513	865	3094	CONF.	COSMIC	YES	YES	N/O	N/O	YES	YES	N/O
COMMENT.....BATSE #6389													
38.21 SEP 97 264 23:25:22 84322 16	0	505	870	3090	CONF.	COSMIC	YES	NO	N/O	N/O	YES	YES	N/O
39.23 SEP 97 266 11:39:21 41961 16	0	498	875	3085	CONF.	COSMIC	YES	NO	N/O	N/O	YES	YES	N/O
40.25 SEP 97 268 22:43:15 81795 2	0	491	880	3080	CONF.	COSMIC	RI	YES	N/O	N/O	YES	YES	N/O
COMMENT.....BATSE #6387													
41.19 OCT 97 292 14:55:54 53754 17	0	401	932	2984	CONF.	COSMIC	YES	NO	N/O	N/O	YES	YES	N/O

APPENDIX 1

Publications Resulting from NASA grant NAG5-2997

WIND Transient Gamma-Ray Spectrometer

K. Hurley, Principal Investigator

1995

Status of the transient gamma-ray spectrometer, H. Seifert, B.J. Teegarden, D. Palmer, N. Gehrels, T.L. Cline, R. Ramaty, A. Owens, K. Hurley, R. Pehl, and N. Madden, *Astrophys. Space Sci.* **231**, 475, 1995.

1996

TGRS observation of the galactic center annihilation line, B.J. Teegarden, T.L. Cline, N. Gehrels, D. Palmer, R. Ramaty, H. Seifert, K. Hurley, D.A. Landis, N.W. Madden, D. Malone, R. Pehl, and A. Owens, *Astrophys. J.* **463**, L75, 1996.

TGRS occultation analysis of the galactic center region, B.J. Teegarden, T. L. Cline, N. Gehrels, K.C. Hurley, A. Owens, D. Palmer, R. Ramaty, and H. Seifert, *Astron. Astrophys. Suppl. Ser.* **120**, 283, 1996.

Gamma-ray observations with the transient gamma-ray spectrometer (TGRS), H. Seifert, B.J. Teegarden, T.L. Cline, N. Gehrels, K.C. Hurley, N. Madden, A. Owens, D.M. Palmer, R. Pehl, and R. Ramaty, *Astron. Astrophys. Suppl. Ser.* **120**, 653, 1996.

1997

TGRS results on the spatial and temporal behavior of the galactic center 511 keV line, B.J. Teegarden, T.L. Cline, N. Gehrels, R. Ramaty, H. Seifert, M. Harris, D. Palmer, K. Hurley, *Proc. 4th Compton Symp.*, 1007, 1997.

Transient Gamma-Ray Spectrometer observation of the bright gamma-ray burst GRB 950822, H. Seifert, B.J. Teegarden, T. L. Cline, N. Gehrels, J. J. M. In 't Zand, D. M. Palmer, R. Ramaty, K. Hurley, N. W. Madden, and R. Pehl, *Astrophys. J.*, **491**, #2, 697, 20 Dec. 1997.